

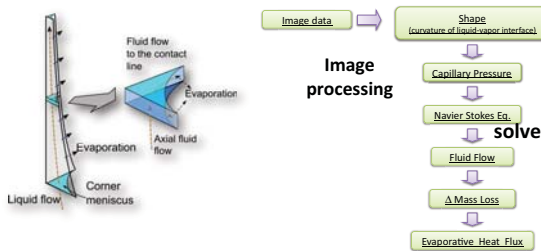
# Experiments and Modeling of Evaporating/Condensing Menisci

Joel Plawsky<sup>1</sup> and Peter C. Wayner, Jr.<sup>1</sup>  
<sup>1</sup> Rensselaer Polytechnic Institute, Troy, NY USA

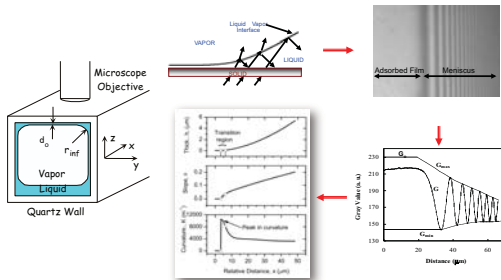
## Introduction or Motivation:

Heat pipes are versatile and reliable devices for transporting heat but little is known about the exact nature of the liquid vapor interface inside. NASA is very interested in these types of system to cool critical components of spacecraft. Our work involves using interferometry/reflectometry to map the vapor-liquid distribution inside a transparent, sealed system called a Constrained Vapor Bubble and determine the transport processes occurring in the extended menisci. We are concerned with both the macroscopic and microscopic details of how the menisci behave.

## Background:



### Interferometry → Curvature

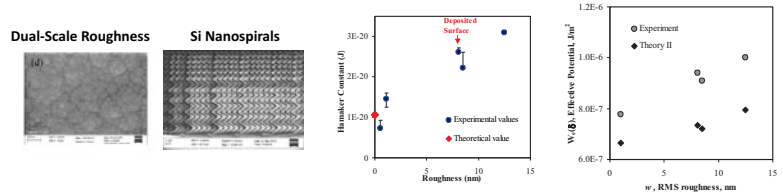


### Vapor-Liquid Distribution for a 94% Pentane/6% Isohexane Evaporating Mixture

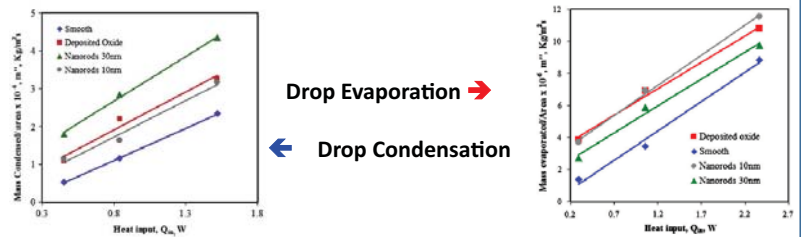


## Results

### Intermolecular Force and Surface Potential Measurements on Rough Surfaces

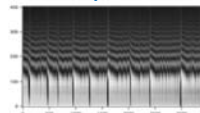


### Nanometer-scale Roughness Can be Tuned to Enhance Heat Transfer – $f$ (Adsorbed Film Thickness)

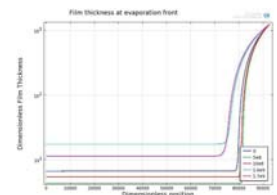


### Meniscus Oscillations

#### Oscillating Meniscus – Strip Chart



- Model simulates large changes in film thickness for small differences in applied temperature (here ~ 0.01 °C)



$$-\eta_e = \frac{E}{K + \eta} - B \left( \frac{K}{K + \eta} \right) \left[ 3S\eta_{cc} - \frac{A}{\eta^3} \right] + S \left[ \eta^* \eta_{cc} \right] + A \left[ \frac{\eta_{cc}}{\eta} \right] + \frac{KM}{Pr} \left[ \frac{-\Omega \eta_{cc}^2 - \Omega \eta_{cc} \eta_{cc} - 2(\eta_{cc}^2/\eta^3)}{K + \eta} - \frac{(K - \Omega \eta_{cc} + 1/\eta^2) \eta_{cc}}{(K + \eta)^2} \right]$$

Evaporation      Surface Tension      Disjoining Pressure      Marangoni

## Discussion and Conclusions:

- Nanoscale surface features can be used to augment heat transfer.
- Interferometry techniques can be used to determine in-situ strength of intermolecular forces governing contact-line behavior.
- Evolution equation models can simulate the qualitative features of experimental data.

## References:

M. Ojha, A. Chatterjee, G. Dalakos, P.C. Wayner, and J.L. Plawsky, Physics of Fluids, 22, 052101 (2010).  
 M. Ojha, A. Chatterjee, F. Mont, E.F. Schubert, P.C. Wayner Jr. and J.L. Plawsky, Int. J. Heat and Mass Transfer, 53, 910-922, (2010).



Joel L. Plawsky ([plawsky@rpi.edu](mailto:plawsky@rpi.edu))  
 Peter C. Wayner, Jr. ([wayner@rpi.edu](mailto:wayner@rpi.edu))

Phone: (518) 276-6049

